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by

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A STUDY OF THE NORMAL VALUE OF DARK ADAPTATION TIME FOR HEALTHY CHINESE PILOTS

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The dark adaptability of pilots crucially affects the quality and safety of their flying exercises. Dark adaptation times are determined from the results of measurements using adaptometers. Using the objective adaptometer Model YAK-I, we have performed the rapid dark adaptation time tests for 1,017 healthy Chinese pilots. Applying statistics for the analysis of our data, we obtained the normal value for dark adaptability.

The Pilots

The 1,017 Chinese pilots tested are from six different units -- four air force convalescent hospitals, troops and an air force school. The medical tests done by the Air Force Health Services had proven all of them to be healthy. The ages of these pilots are from 16 to 50 (see Table 1). All of them have the visual acuity better than 1.0,

normal color vision, normal visual field and normal retina. They have neither night-blind symptoms nor any other eye diseases.

Table 1 Age Distribution of the 1017 Pilots

	group by age (year)				total
	16~	20~	30~	40~	
No. of pilots	233	334	300	150	1017
percentage	22.9	32.8	29.5	14.8	100

The Test Method

Our tests were done in an ordinary testing room using the objective adaptometer Model YAK-I. After a rest of 10 to 15 minutes in the testing room, the pilots had the electrodes attached onto their skin near their canthi and between their eyebrows. Then they were instructed to sit down and to press both of their eyes hard onto the window of the instrument. First, the machine gave bright adaptation with the luminosity of 2000 asb for two minutes followed by dark adaptation showing light stripes with its luminosity of 0.02 asb and rotating at the angular speed of 30° per second. Perceiving eyeball quiver, the reaction of human beings in seeing moving light signals in darkness, the instrument displayed digitally the exact dark adaptation time desired.

Results and Analysis

The results from rapid dark adaptation time tests upon the 1017 pilots yielded the minimum value of 8 seconds and the maximum value of 60 seconds as shown in Table 2. The upper limit of 99% normal value is 45.6 seconds as the result by applying the Percentage Method (1). Dark adaptation times seem to get longer with the increasing age as can be seen in Table 3.

Table 2 Distribution of Rapid Dark Adaptation Time

	dark adaptation time (second)							total
	0~	10~	20~	30~	40~	50~	60~	
No. of pilots	90	572	279	58	14	3	1	1017
percentage	8.9	56.2	27.4	5.7	1.4	0.3	0.1	100

Table 3 Upper Limit of Normal Value of Pilots Rapid Dark Adaptation Time

	group by age (year)				total
	10~	20~	30~	40~	
99% normal value (second)	32.2	45.3	47.5	49.0	45.6

Discussion

1. The criteria in determining rapid dark adaptation times by the eyeball quiver graph: The objective adaptometer Model YAK-I was used to determine rapid dark adaptation times for 1,017 healthy Chinese pilots. The adaptometer gave bright adaptation for two minutes with the light luminosity of 2000 asb, then the dark adaptation with the weak light stripes of 0.02 asb rotating at 30° per second. Statistical analysis on these test results gave 45.6 seconds as the upper limit of dark adaptation time. For convenience we round it up to the integer — 50 seconds. Therefore our preliminary suggestion is to set 50 seconds or less to be the normal range of dark adaptation time for healthy pilots.

2. The criteria of rapid dark adaptation times: All the adaptometers used previously (such as ADM adaptometer made by Soviet Union, night vision tester currently used by us (2), etc.) have recommended 1 minute or less as the normal value. However, YAK-I showed 50 seconds, 10 seconds less than those by all of the previous instruments. Our question is now why the dark adaptation times became shortened by measuring the time of eyeball quiver at perceiving moving light signals. Following is the explanation in view of instrument construction, test methods as well as the physical and mental reaction process of human beings. Regarding instrumental construction, we note that different adaptometers provide different kinds of light signals. To stimulate pilots' vision, our YAK-I adaptometer shows moving light stripes with their area as wide as of 150x130 mm^2 corresponding to a 29° visual angle which cover the whole visual field of a person so that he can easily detect the signal

due to the relatively large amount of light coming onto his retina. Besides, this type of adaptometer reports dark adaptation time automatically without delay. On the other hand, all the previous adaptometers provide static signal in small size. For example, night vision testers show fixed vision signals in the form of little "+" or "=" inside a circle with its diameter of 40mm corresponding to the narrow visual angle of 7.4°. In order to be able to detect them, one has to focus on the field within an appropriate angle. Furthermore, one has to push the button to make the adaptometer count time instead of automatical instrumental recording. This is the factor affecting adaptation time caused by the difference in instrumental construction. Next, let's consider the difference of testing methods by using two different kinds of adaptometers. Once a retina of a person perceives stimulation due to moving light stripe, this perception is propagated by optical nerve to produce eyeball quiver and YAK-I counts dark adaptation time immediately. This is just a simple process of neural reaction thus providing quick and accurate information. In case of other types of adaptometers, a person has to go through a so-called thinking process. His cerebral cortex has to analyze and judge whether that he has seen is a "+" or "=" once his retina perceives light. After that, he has to make his hand push the button manually so that the digital indicator of the adaptometer can count the time. It's obvious that this method should yield longer dark adaptation time as it includes additional processes of two complex reactions. According to the calculations on neural pulse propagation, the time for a light beam reaching the retina and then producing a neural pulse plus the time for the pulse to reach cortex

is about 0.1 second, it takes 0.4 second for a brain to recognize this signal, and then mental judgement and reaction by manual motion take approximately 6 seconds. Therefore, in applying YAK-I pure neural reaction is a short process (about 1 second) while in case of other adaptometers the complicated reaction processes require much longer time (about 6 seconds). Lastly, according to psychology, "a moving object on a fixed backgroung is more easily perceived by human eyes than a static object is" (3), and the time for human eyes to identify a moving signal is also different from a static one (the latter is more difficult and takes longer time). Besides, the peripheral retina of human being is mainly made of bacillar cellules which are extremely sensitive to moving objects thus playing important role in dark adaptation. This is another reason why moving light signals provided by YAK-I are more easily detected. In summary, YAK-I gives shorter dark adaptation time which is more accurate than those shown by all the previous adaptometers. Therefore, it's more reasonable to set the dark adaptation time to be 50 seconds according to both physiology and psychology.

Finally, let's consider the necessary luminosity and working condition for pilots flying at nights. According to the report from Naval Force of USA, study on luminosity inside an F-18 airplane suggested the standard of average minimum luminosity inside a cabin for a flying pilot to be 0.34 to 0.65 asb which is basically consistent with the minimum luminosity measurements on meter panels in our August-First airplane which is 0.25 asb. According to the report by Kabayamatosio et al, the minimum luminosity on the meter panels inside Japan airplanes while landing is 1 to 2 asb.

Therefore, our YAK-I adaptometer with its signal luminosity of 0.02 asb for testing dark adaptibility is sufficient to guarantee normal performance of a pilot sitting in his cabin seat during night flying.

Conclusion

As the result of rapid dark adaptation times tests on 1017 healthy Chinese pilots, this paper recommends the objective dark adaptometer Model YAK-I as the ideal instrument and suggests the range of normal value for rapid dark adaptation time to be 50 seconds or less.

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A STUDY ON THE NORMAL VALUE OF DARK ADAPTATION TIME FOR THE HEALTHY CHINESE FLIERS

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Dark adaptation times of 1017 healthy Chinese fliers aged from 16 to 50 years with visual acuity better than 1.0 and without ocular diseases, were examined using objective dark adaptometer, model YAK-I. After adapting to light field of luminance of 2000 asb for 2 minutes, subjects were exposured to dark moving grating of luminance of 0.02 asb at 30°/sec. The rapid dark adaptation time of all subjects ranged from 8 to 60 sec. Thus, the normal value of dark adaptation time was statistically established as in 50 sec.

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